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DARLINGTON UNIT 2 MOISTURE SEPARATOR REHEATER ACOUSTIC RESONANCE

Report No 91-9-K

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ABSTRACT

On runup to full load during first commissioning, the Darlington Unit 2 Moisture Separator Reheaters exhibited high levels of noise at discreet frequencies. The manufacturer attributed the noise to the coincidence of a cavity resonance with the tube bundle vortex shedding frequency. The manufacturer's solution to the problem was to partition the tube bundle cavity into three segments to preclude any tuning phenomenon. This report describes the measurements taken on first runup to full load after the MSR's were modified.

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740627-142-452	825.44	February 4, 1991	91-9-K

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EXECUTIVE SUMMARY

On runup to full load during first commissioning, the Darlington Unit 2 Moisture Separator Reheaters exhibited high levels of noise at discreet frequencies. The manufacturer attributed the noise to the coincidence of a cavity resonance with the tube bundle vortex shedding frequency. The manufacturer's solution to the problem was to partition the tube bundle cavity into three segments using splitter plates to preclude any tuning phenomenon.

After modification, the MSR's were monitored for both discreet frequency vibration and splitter plate impacting or rattling. The unit was loaded with only the first stage of reheat until full load was reached; then the second stage of reheat was valved in. Discreet tones became evident from the start of loading, peaked in amplitude at about 600 MWe, dropped off significantly near full load, then all but disappeared at full load and full reheat. There was no direct evidence of splitter plate impacting.

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To Mr. M.A. Machacek
Manager of Engineering
Darlington Project

DARLINGTON UNIT 2 MOISTURE SEPARATOR REHEATER
ACOUSTIC RESONANCE

1.0 INTRODUCTION

At the request of Darlington Engineering, the Plant Equipment Dynamics Section assisted with the vibration problem of the Darlington Unit 2 Moisture Separator Reheaters (MSR's). The initial objective was to provide assistance to the MSR manufacturer in making selected noise and vibration measurements. Later on, the scope was expanded to review the manufacturer's explanation of the noise/vibration source and proposals for modifications. In addition, vibration monitoring of the modified MSR's was required.

The results of the measurements taken on the original (unmodified) MSR's have been documented by the manufacturer/1/. The manufacturer also reported the results of their analytical investigations which led them to attribute the high noise levels to a cavity resonance and propose the splitter plate modifications/2,3/. Ontario Hydro staff agreed with this proposal/4/ and the modifications was implemented in both Units 1 and 2.

This report presents the results of the vibration monitoring of the Unit 2 MSR's during the first runup to full load after the modifications were implemented.

2.0 TEST EQUIPMENT AND PROCEDURE

Four Bruel and Kjaer accelerometers Type 4382 were magnet-mounted on the outer shells of the MSR's at locations indicated in Figure 1. Each signal was conditioned and amplified using a B&K Type 2635 charge amplifier operating in the acceleration mode, 2 Hz to 30 kHz. The signals were recorded in pairs on a Sony Type TCD-D10 DAT recorder and analyzed on a Nicolet FFT Spectrum Analyzer Type 660B. The recorded signal bandwidth was 20 Hz to 20 kHz. The layout is shown schematically in Figure 1.

The test procedure consisted of monitoring the four locations on the MSR shells while the unit was brought up to full load in 200 MW increments. Only the first stage of reheat was used during the runup. Once the unit was stabilized at maximum load, the second stage of reheat was valved in.

3.0 TEST RESULTS

The test results are presented in four formats:

a) A single plot showing an overview of the variation of frequency and frequency range with load (same presentation as the manufacturer's), Figure 2;

b) A table summarizing the individual frequencies and their levels at each test condition, Table 1;

c) Typical frequency spectra comparing the frequencies and the RMS levels over a bandwidth in the region of the tones for the modified and unmodified MSR's under the worst case conditions, Figures 3 and 6; and

d) Vibroacoustic acceleration spectra comparison to determine the existence of splitter plate rattling, Figure 7.

4.0 DISCUSSION OF RESULTS

4.1 Tone Generation

The first evidence of tones occurred at 0 MWE soon after unit synchronization to the grid. The frequencies were 890, 935 and 960 Hz, as indicated in Table 1. As the unit was loaded, the tones increased in frequency and became distinctly audible at 200 MWe. The amplitudes reached a peak of 600 MWe, but then declined steadily until at maximum load they were just perceptible. When the second stage of reheat was added, the tones on the south MSR completely disappeared, and those on the north MSR were barely perceptible.

Over the range of load, the frequencies steadily increased in value, at full load reaching 1060 Hz on the north MSR and 1050 Hz on the south MSR. This is similar to the situation that occurred on the original (unmodified) MSR'S, although the frequencies were different (700 to 790 Hz approximately). The introduction of these "new" frequencies may be partially explained by considering (a) the effect of the splitter plates on the gross flow through the tube bundles and (b) a possible local effect in the first row or two above and below a plate.

In the first case, the introduction of splitter plates will reduce the cross-sectional area by about 5% from the original/5/; hence the flowrate will increase somewhat. This is not, however, enough to explain this difference in frequencies.

In the second case, especially on the upstream side, the steam flow is disturbed by the 15 mm by 25 mm rectangular bars to which the splitter plates are attached. This could cause a more substantial increase in the local flow velocity, thereby shifting the vortex shedding frequency significantly. Because this would be a localized phenomenon, any coincidence with a new acoustic resonance may be at a reduced intensity, compared to the case where the full cross-section is active. The observed levels tend to substantiate this hypothesis. A more detailed examination is beyond the scope of this report and would require knowledge of the process condition throughout the tube bundles.

Fortunately, the apparent tuning of the new acoustic frequency with the new vortex shedding frequency peaked at process conditions corresponding to 600 MWe. As the output increased from then on, this coupling was substantially reduced, until at full load and full reheat it was almost completely absent.

4.2 Splitter Plate Rattling

An examination of Figure 7 shows that the energy level between 3 kHz and 10 kHz (discounting the harmonics of 525 Hz for the modified MSR) is similar for both the modified and unmodified MSR's. This indicates that any impacting or rattling of the splitter plates, if present, is at a low level. This conclusion is contingent upon the assumption that there is a direct transmission path between the internal components being impacted and the outer shell where the transducer is located. The transducer locations were originally chosen to meet this requirement, as much as practically possible.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 At conditions of full load and full reheat, the Unit 2 Moisture Separator Reheaters (modified with splitter plates) operate at low levels of flow-induced vibration.

5.2 At reduced load and/or reduced degree of reheat, some of the MSR internal components may vibrate at levels detrimental to their long-term integrity.

5.3 Unit 1 MSR's should be monitored in a similar fashion to Unit 2 if audible single-tone noise is detected during runup to full load.

5.4 There is no direct evidence of splitter plate rattling; however, it is recommended that a vibroacoustic check be made after some months of operation. If no deterioration is found, additional surveys would not be required.

5.5 The splitter plates and adjacent tubes should be inspected for fretting damage and wear during the warrantee outage (1991).

5.6 The manufacturer should perform further analysis to explain the appearance of the "new" frequencies.

Approved:

G.J. Clarke
Manager
Mechanical Research Department

Submitted:

J.W. Forest
Unit Head - Process Equipment and Fluid Dynamics
Plant Equipment Dynamics Section
Mechanical Research Department

JWF:is

REFERENCES

1. Minutes of Meeting, Darlington NGS, MSR Noise, D. Craig, Aug 2/90.
2. Progress Report No 1, P. von Bockh, ABB, Inc, Aug 8/90/.
3. Progress Report No 2, P. von Bockh, ABB, Inc, Sept 9/90.
4. Minutes of Meeting, Darlington Unit 2 MSR Noise Problem, D.F. Meraw, Aug 15/90.
5. Personal notes, meeting at Darlington NGS, J.W. Forest, Oct 3/90.

TABLE 1
DARLINGTON UNIT 2 MSR
TONE FREQUENCIES AND AMPLITUDES

POWER LEVEL: [MWe]	LOCATION NUMBER:	FREQUENCY [HZ]	ACCELERATION LEVEL: [m/s²]	FREQUENCY [HZ]	ACCELERATION LEVEL: [m/s²]	REMARKS:
0	1	615 705	0.008 0.018	640 1570	0.009 0.008	SLIGHT TRACE OF SIGNAL
0	6	785	0.007	1285	0.011	— " —
0	8 & 16	broad band spectrum < 0.006 m/s/s				
0	8	890 960	0.188 0.168	935	0.167	FIRST EVIDENCE OF TONE
22	1	895 980	0.184 0.271	930	0.266	
	6	895 950	0.355 0.438	920	0.291	
	8	895 1000	0.510 0.217	950	0.603	
	16	900 1000	0.467 0.291	955	0.761	
200	1	980 1055	0.921 1.09	1005	4.88	
	6	980 1055	5.30 3.71	1005	3.40	7.92 OVERALL
	8	985 1060	1.82 1.97	1005 1145	2.88 6.14	8.02 OVERALL
	16	950 1005 1140	1.98 3.94 2.87	985 1060	2.43 1.39	7.14 OVERALL
400	1	1000	7.24	1030	7.30	11.3 OVERALL
	6	1000	3.35	1030	1.92	4.12 OVERALL
	8	1000 1055	9.90 1.19	1025 1160	9.90 1.25	15.1 OVERALL
	16	1000 1055	4.62 1.47	1025 1160	5.90 2.08	6.63 OVERALL

TABLE 1 (CONT'D)
DARLINGTON UNIT 2 MSR
TONE FREQUENCIES AND AMPLITUDES

POWER LEVEL: [MWe]	LOCATION NUMBER:	FREQUENCY [HZ]	ACCELERATION LEVEL: [m/s^2]	FREQUENCY [HZ]	ACCELERATION LEVEL: [m/s^2]	REMARKS:
600	1	1015	5.05	1040	6.78	9.42 OVERALL SL = 98.5 dBA
	6	1015	5.90	1040	2.27	7.24 OVERALL
	8	1015 1065	8.05 3.73	1035	7.36	12.9 OVERALL SL = 94.5 dBA
	16	1015 1060	5.47 1.26	1035	11.7	13.4 OVERALL
800	1	1020	8.80	1050	5.80	SL = 96.2 dBA
	6	1020	4.82	1050	0.92	
	8	1020	4.79	1045	11.3	12.7 OVERALL SL = 94.0 dBA
	16	1025	5.83	1045	2.02	6.8 OVERALL
910	1	1025	8.1	8.48 OVERALL		FIRST STAGE REHEAT ONLY
	6	1025	2.94	3.66 OVERALL		SL = 94.3dBA
	8	1050	12.6	13.5 OVERALL		SL = 92.0 dBA
	16	1025	4.15	4.74 OVERALL		
910	1	1060	0.70	2.07 OVERALL		FULL REHEAT
	6	1060	1.95	2.86 OVERALL		SL < 90 dBA
	8	525 1050	0.53 0.50	605 1575	0.29 0.34	2.23 OVERALL SL < 90 dBA
	16	525	0.26	1050	0.33	1.99 OVERALL

LAYOUT SCHEMATIC

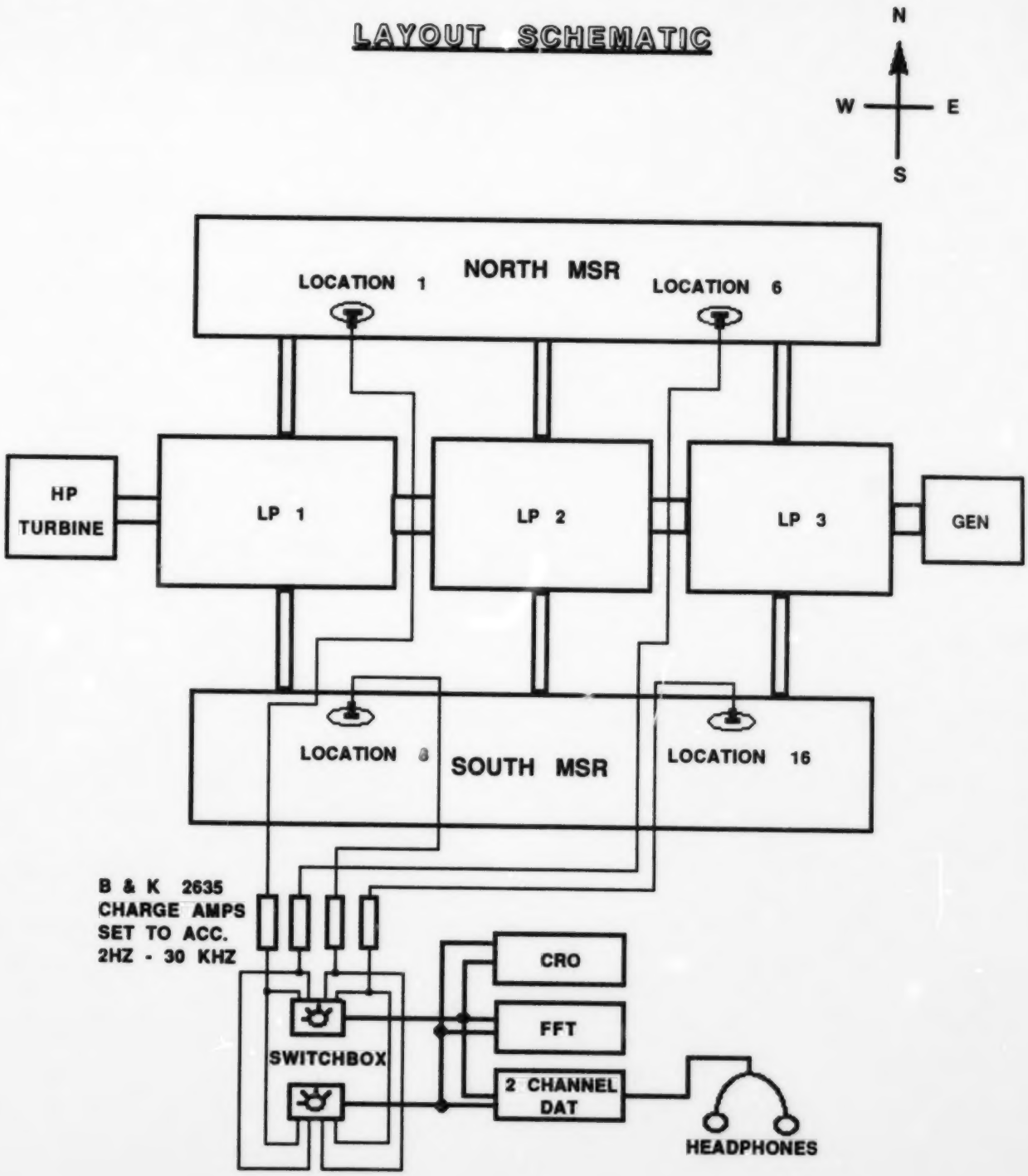

FIGURE 1

DARLINGTON GS - UNIT 2 MSR
TONE FREQUENCIES vs OUTPUT POWER

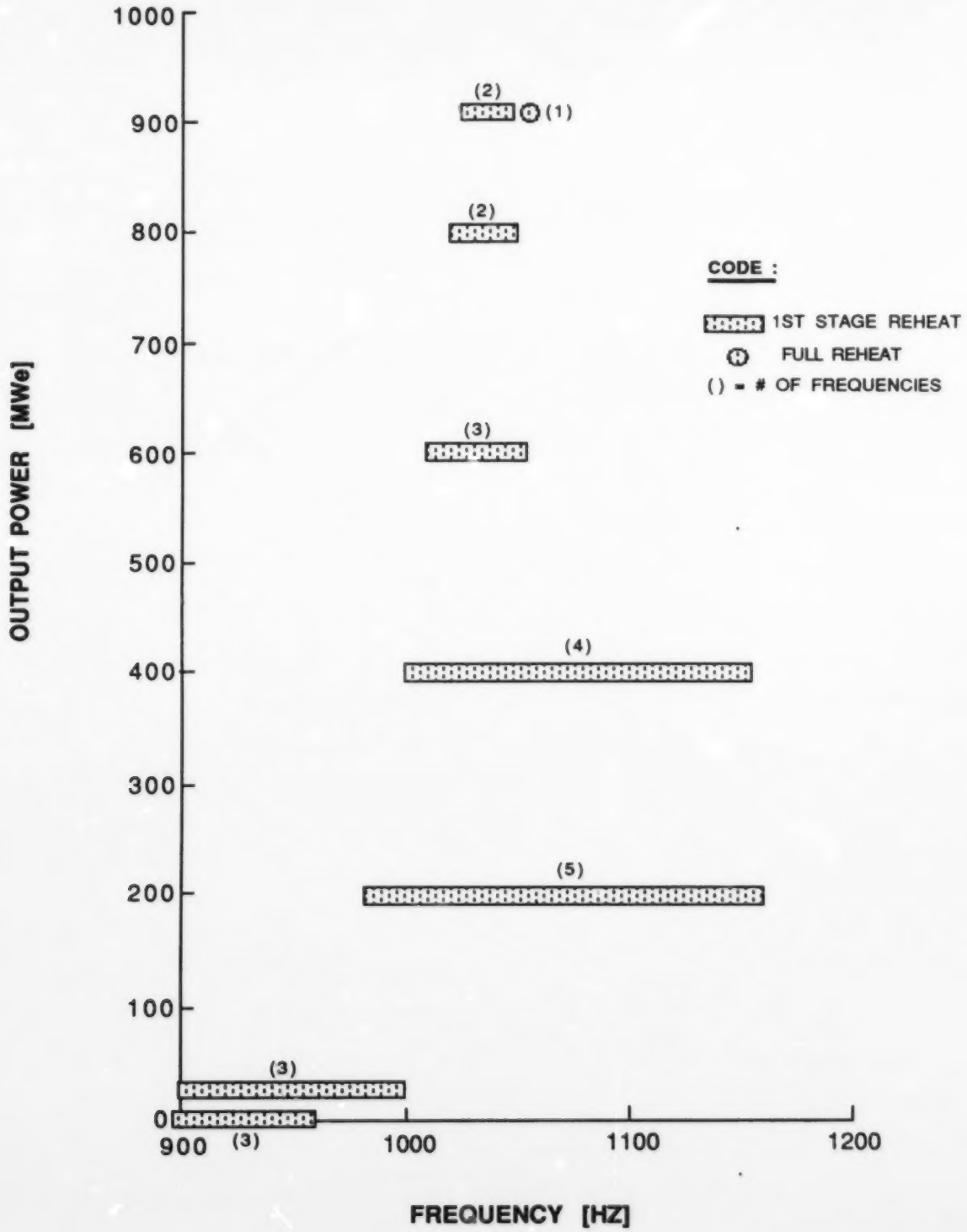

FIGURE 2

WORST CASE COMPARISON - VELOCITY
LOCATION 8

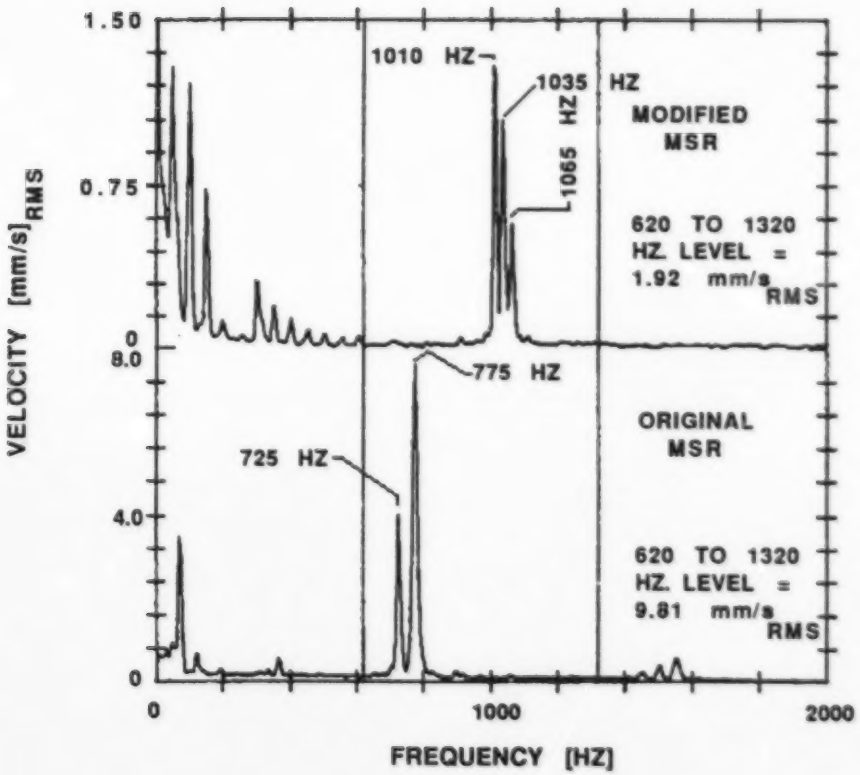

FIGURE 3

WORST CASE COMPARISON - ACCELERATION
LOCATION 8

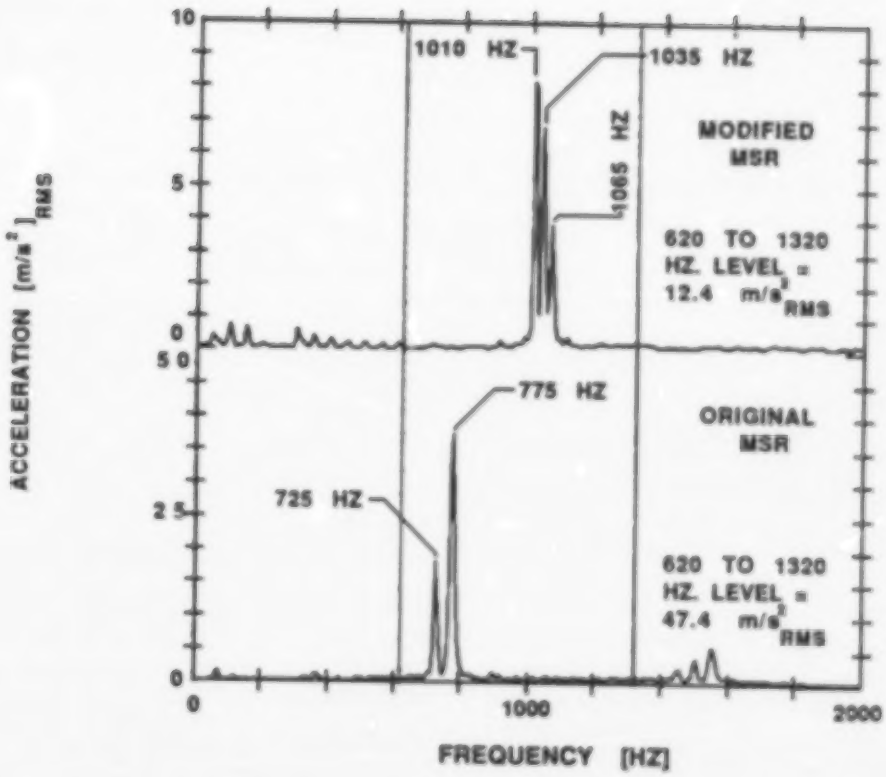

FIGURE 4

WORST CASE COMPARISON - VELOCITY
LOCATION 16

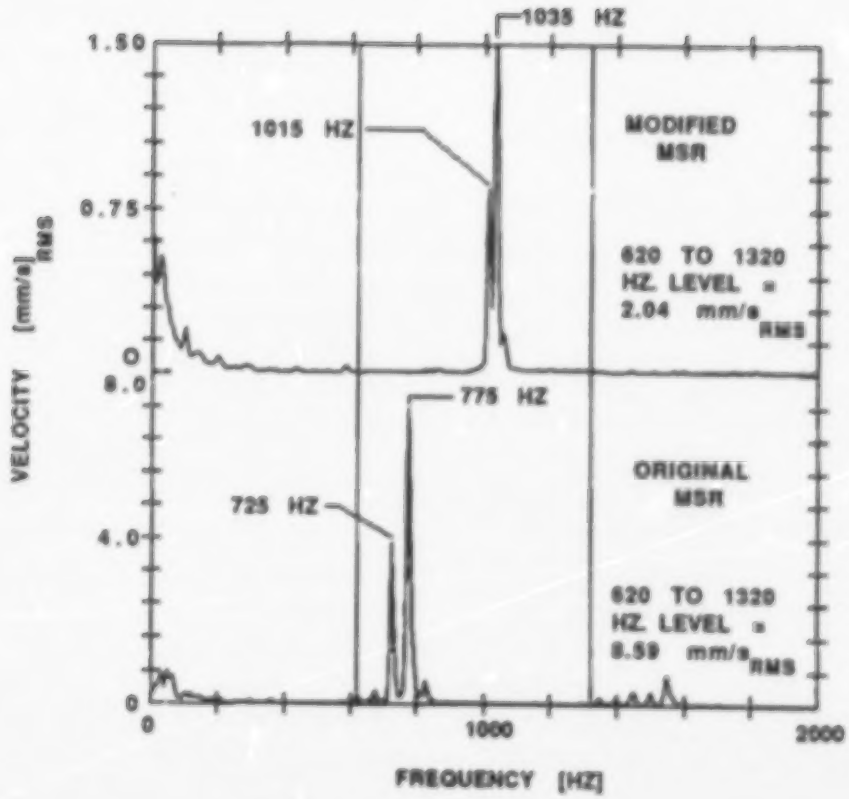

FIGURE 5

WORST CASE COMPARISON - ACCELERATION
LOCATION 16

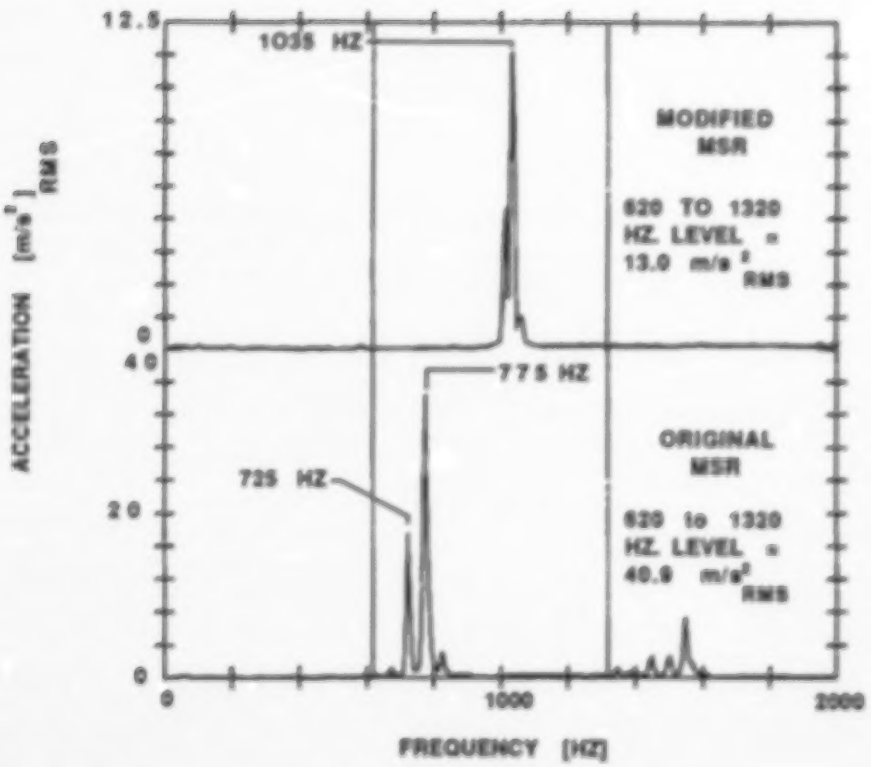

FIGURE 9

VIBROACOUSTIC COMPARISON AT FULL LOAD AND FULL REHEAT

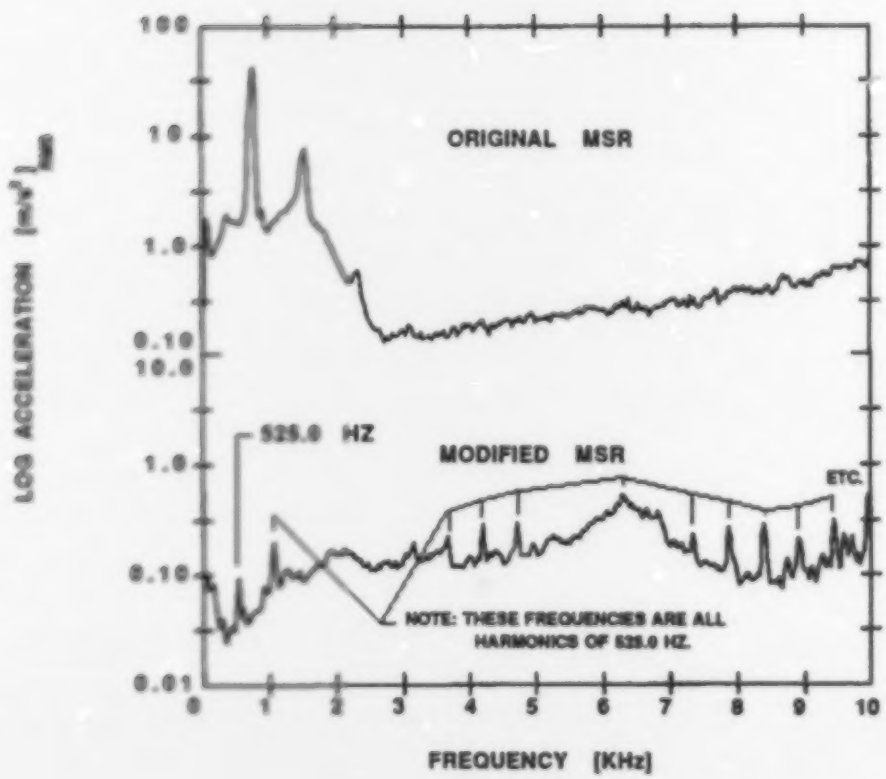

FIGURE 7